



Practical Use of SpectrAA Series for Multielement Analysis

Application Note

Atomic Absorption

Author

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Introduction

The SpectrAA system is designed for automatic multi-element analysis in flame furnace and hydride modes, up to 12 elements in 67 samples (45 in furnace mode) with minimum operator supervision. When operating in the flame mode an operator should be near at hand but can be carrying out other tasks.

When operating in the furnace mode the system can be left unattended as there are no flammable gases and no exposed ignition source hence it can be left to operate overnight.

A scenario is described for analysis by flame and shows how even a very complex analytical program is easily handled by the SpectrAA.

The components of the system are:

SpectrAA-30 or SpectrAA-40 Atomic Absorption Spectrophotometer
PSC-56 Programmable Sample Changer
GTA-96 Graphite Tube Atomizer
VGA-76 Vapor Generator Accessory
DS-15 Data Station

The above units except for the DS-15, are only fitted with an on/off power switch. Programming and control of each unit in the system is through the DS-15 keyboard but no computer programming knowledge is required by the operator. In fact the system is designed for one finger operation using the "fill in the form" (F.I.T.F) method developed by Agilent Technologies.



Agilent Technologies

Versatility and ease of use has been achieved in the system design. The user friendly programming is designed to lead the operator through the correct procedures.

At power up the DS-15 screen displays 3 modes of operation. The operator selects one mode using the soft keys labelled:

DEVELOP METHOD
MODIFY METHOD
AUTOMATIC RUN

DEVELOP METHOD used by a chemist to set up and store methods for the use of other staff.

MODIFY METHOD used in a similar manner.

AUTOMATIC RUN used for routine automatic analysis.

Flame Analytical Procedure

The following scenario shows how all the facilities of the system may be used to perform a complex analytical program.

A laboratory has the following samples for analysis:

- 20 steel samples for the determination of chromium, copper, lead, manganese, molybdenum, nickel and silicon.
- 10 water samples for the determination of iron, sodium and arsenic.
- 10 slag samples for the determination of calcium, iron and silicon.

Steel Samples

Analytical method development has shown that most of the elements in the steel samples can be determined by normal calibration using mixed standards containing iron. The SpectrAA- will be calibrated in the concentration mode using the integration measurement mode for these elements.

Chromium and nickel concentrations must be determined accurately over a narrow range and bracketing standards calibration will be used for these determinations. High precision of measurement is also required thus PROMT mode will be used.

PROMT is Precision Optimised Measurement Time. This allows the operator to specify the precision of measurement

required (from 0.1% to 99.9%) and set a default time (1 to 500 seconds) for the system to achieve this. If the system is unable to achieve the precision within the default time specified, measurement will stop and the precision achieved printed out with the result. (The smaller the absorbance signal the longer the measurement time required to obtain a given precision).

This facility is extremely useful when high precision is required but the element concentration (and thus absorbance) is expected to vary widely. The operator can set the default time for the lowest expected absorbance knowing that higher absorbances will be read in a shorter time with no loss of precision or waste of analysis time.

The concentrations of lead are expected to be low thus the air-acetylene burner will be used to obtain higher sensitivity. (NOTE When high sensitivity is not required a burner change can be avoided by using a nitrous oxide-acetylene burner for an air-acetylene flame. This eliminates programming a "Pause" to change burners). PROMT mode could be used for measurement but in this case the mean of three replicate readings of 7-second integration is sufficient for the analytical requirements.

Chromium forms ferro-chrome compounds in the air-acetylene flame and will therefore be determined using the nitrous oxide-acetylene flame. This flame will also be used to determine molybdenum and silicon. All three elements will be determined using five second integration and three replicates.

A delay of five seconds is programmed when using continuous aspiration so that each solution will be aspirated for five seconds before any readings are taken. This ensures that the previous solution is washed out of the nebulizer/burner system. Cross contamination is prevented and the determinations will be more accurate. In addition a RINSE RATE and RINSE TIME may be programmed if required (where sample concentrations cover a wide range).

RECALIBRATION RATE and/or RESLOPE RATE are selected on previous experience with the samples and elements. Typical values could be reslope 10, recalibration 20.

Up to five standards may be used for each element calibration. 5 mixed standards will be loaded into the sampler carousel, but the number used will vary from element to element (see Table 1).

Table 1.

Program	Element	Delay	Standards					Sample		Reslope	Recal	Flame	Notes	
			1	2	3	4	5	First	Last					
15	Fe	2	*	*				1	20	—	10	AA) Std) Addn)	
17	Ca	1	*	*				11	20	—	—	NA		
18	Si	—	*	*				11	20	—	—	NA		
PAUSE (change carousel)														
13	Cr	—	*	*				31	50	—	10	NA	Reslope	
19	Si	—	*	*	*	*		21	45	14	—	NA		
23	Mo	—	*	*	*	*		41	50	—	—	NA		
9	Na	3	*	*	*	*		1	10	—	—	AA		
1	Cu	—	*	*	*	*		21	50	15	30	AA		
7	Ni	—	*	*	*	*		31	50	—	10	AA		
8	Mn	—	*	*	*	*		27	45	—	—	AA		
PAUSE (change burner)														
2	Pb	2	*	*	*	*		31	50	—	10	AA	Std Addn	
PAUSE (change carousel, connect VGA-76)														
10	As	—	*	*				1	10	—	—	AA		

Although RECAL will not be used for program 1, it is included here as it is part of the stored program.

AA = Air-Acetylene

NA = Nitrous Oxide-Acetylene

Water Samples

EPA methods specify standard additions calibration for water analysis. Iron will be determined by this method using the air-acetylene flame burning on a nitrous oxide-acetylene burner. Continuous aspiration would normally be used for water samples but in this case the program "Fe in Slag" will be used which uses the micro-sampling technique. Thus two different sample types can be run on one program, the recalibration rate being defined by the number of water samples.

Arsenic will also be determined by standard additions calibration but using hydride generation. Sodium will be determined by EMISSION using normal calibration.

Two addition standards will be prepared from sample 1 and used to produce the calibration graph. The other 9 samples will be measured against this calibration because the matrices will be very similar.

Slag Samples

As the matrices will be complex and variable all elements will be determined using STANDARD ADDITIONS calibration. The dissolved solids concentration will be very high therefore continuous aspiration will not be used. Instead, the MICRO-SAMPLING feature of the PSC-56 will be used and measurements made in peak height mode.

In micro-sampling the sampling probe dips into the solution for a programmed time. During this time a certain volume of liquid is drawn into the flame, the longer the time the greater the volume (for a one second dip about 350 μ L). An integration "window" of eight seconds is set on the system. This allows enough time for the solution to travel through the nebulizer/burner system into the optical path to be measured. A volume of 200 μ L or more will give the same signal as continuous aspiration, 100 μ L will give about 80% and 50 μ L about 50% of the continuous aspiration signal. Micro-sampling is also useful when only small volumes of sample are available [1,2,3,4].

A RINSE between each sample and a SAMPLE FLUSH will also be programmed. Using sample flush the probe dips into a solution for half a second, the slug of liquid is drawn through the capillary "flushing out" any traces of the previous solution aspirated: no measurement is made on this solution. After about 10 seconds the probe dips into the solution for the specified dip time and the signal produced is measured.

Iron will be determined using the air-acetylene flame, silicon and calcium using the nitrous oxide-acetylene flame, both flames being run on the nitrous oxide-acetylene burner.

Typical system parameters for some elements are shown in Figures 1 to 6.

PROGRAM 15 Fe in Slag

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	STANDARD ADDITIONS
MEASUREMENT MODE	PEAK HEIGHT
LAMP POSITION	2
LAMP CURRENT (mA)	5
SLIT WIDTH (nm)	0.2
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	248.3
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	AUTO MICRO
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	8.0
REPLICATES	3
BACKGROUND CORRECTION	ON
AIR FLOW (L/min)	13.5
ACETYLENE FLOW (L/min)	2.00
RINSE RATE	1
RINSE TIME (sec)	5.0
DIP TIME (sec)	0.0
SAMPLE FLUSH	YES
RECALIBRATION RATE	10

Figure 1.

PROGRAM 7 Ni in Steel

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	BRACKETING STANDARDS
MEASUREMENT MODE	PROMT
LAMP POSITION	8
LAMP CURRENT (mA)	4
SLIT WIDTH (nm)	0.5
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	351.5
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	AUTO NORMAL
DELAY TIME	5
TIME CONSTANT	0.05
DEFAULT TIME (sec)	10.0
PRECISION	0.2
BACKGROUND CORRECTION	OFF
AIR FLOW (L/min)	13.5
ACETYLENE FLOW (L/min)	2.00
RINSE RATE	1
RINSE TIME (sec)	5.0
RECALIBRATION RATE	10

Figure 2.

PROGRAM 9 Na in Water

INSTRUMENT MODE	FLAME EMISSION
CALIBRATION MODE	CONCENTRATION
MEASUREMENT MODE	INTEGRATION
SLIT WIDTH (nm)	0.5
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	589.0
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	AUTO NORMAL
DELAY TIME	5
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	3.0
REPLICATES	3
AIR FLOW (L/min)	13.5
ACETYLENE FLOW (L/min)	2.00
RINSE RATE	1
RINSE TIME (sec)	5.0
RECALIBRATION RATE	0
RESLOPE RATE	0

Figure 3.

PROGRAM 10 As in Water

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	STANDARD ADDITIONS
MEASUREMENT MODE	INTEGRATION
LAMP POSITION	7
LAMP CURRENT (mA)	10
SLIT WIDTH (nm)	0.5
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	193.7
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	AUTO NORMAL
DELAY TIME	35
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	5.0
REPLICATES	3
BACKGROUND CORRECTION	OFF
AIR FLOW (L/min)	13.5
ACETYLENE FLOW (L/min)	2.00
RINSE RATE	1
RINSE TIME (sec)	5.0
RECALIBRATION RATE	0

Figure 4.

PROGRAM 13 Cr in Steel

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	BRACKETING STANDARDS
MEASUREMENT MODE	PROMT
LAMP POSITION	8
LAMP CURRENT (mA)	7
SLIT WIDTH (nm)	0.2
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	520.8
FLAME	N2O-ACETYLENE
SAMPLE INTRODUCTION	AUTO NORMAL
DELAY TIME	5
TIME CONSTANT	0.05
DEFAULT TIME (sec)	10.0
PRECISION	0.2
BACKGROUND CORRECTION	OFF
N2O FLOW (L/min)	11.0
ACETYLENE FLOW (L/min)	6.00
RINSE RATE	1
RINSE TIME (sec)	5.0
RECALIBRATION RATE	10

Figure 5.

PROGRAM 18 Si in Slag

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	STANDARD ADDITIONS
MEASUREMENT MODE	PEAK HEIGHT
LAMP POSITION	2
LAMP CURRENT (mA)	10
SLIT WIDTH (nm)	0.2
SLIT HEIGHT	NORMAL
WAVELENGTH (nm)	251.6
FLAME	N2O-ACETYLENE
SAMPLE INTRODUCTION	AUTO MICRO
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	8.0
REPLICATES	3
BACKGROUND CORRECTION	ON
N2O FLOW (L/min)	13.5
ACETYLENE FLOW (L/min)	9.00
RINSE RATE	2
RINSE TIME (sec)	5.0
DIP TIME (sec)	0.5
SAMPLE FLUSH	YES
RECALIBRATION RATE	0

Figure 6.

Programming the Automatic Run

It will be useful to draw up a table (Table 1) when planning the analysis. This can then be used when compiling the sequence control page on the DS-15 (Figure 8).

Elements requiring standard additions calibration will be determined first.

AUTOMATIC RUN soft key is pressed and SEQUENCE SELECTION page (Figure 7) is displayed. The relevant programs are selected on this page and the soft key for SEQUENCE CONTROL pressed. The programs selected are displayed by number and title on the left side of the screen (Figure 8).

PROGRAM 15		Fe in Slag	
NO. 1 BLANK		REPLICATE 1	
ABSORBANCE		STANDARD ADDN'S BC ON	
PEAK HEIGHT		8.0 (sec) AIR-ACETYLENE	
PRINTING			
SEQUENCE		SELECTION	
1. Cu in Steel		16. Si ORE SAMPLES	
2. Pb in Steel		17. Ca in Slag	
3. Pb in Water		18. Si in Slag	
4. Cu H2O		19. Si in Steel	
5.		20. Al Water Treatment	
6.		21.	
7. Ni in Steel		22. Al ORE SAMPLES	
8. Mn in Steel		23. Mo in Steel	
9. Na in Water		24.	
10. As in Water		25. Ti ORE SAMPLES	
11. As ORES		26.	
12.		27.	
13. Cr in Steel		28.	
14. Fe in Water		29.	
15. Fe in Slag		30. Ni in WATER	
SEQUENCE	15 17 18 13 19	23 9 1 7 8	2 10
CLEAR			
SEQUENCE			

Figure 7.

PROGRAM 15		Fe in Slag	
NO. 1 BLANK		REPLICATE 1	
ABSORBANCE		STANDARD ADDN'S BC ON	
PEAK HEIGHT		8.0 (sec) AIR-ACETYLENE	
PRINTING			
SEQUENCE CONTROL			
PROGRAM NO.	PROGRAM ID.	DELAY (min)	FIRST SAMPLE LAST SAMPLE FIRST MEASUREMENT
15. Fe in Slag		2	1 20 CALIBRATION
17. Ca in Slag		1	11 20 CALIBRATION
18. Si in Slag		0	11 20 CALIBRATION
13. Cr in Steel		0	31 50 CALIBRATION
19. Si in Steel		0	21 45 CALIBRATION
23. Mo in Steel		0	41 50 CALIBRATION
9. Na in Water		3	1 10 CALIBRATION
1. Cu in Steel		0	21 50 RESLOPE
7. Ni in Steel		0	31 50 CALIBRATION
8. Mn in Steel		0	27 45 CALIBRATION
2. Pb in Steel		2	31 50 CALIBRATION
10. As in Water		0	1 10 CALIBRATION
START AT PROGRAM NO.	15	SAMPLE NO.	1 WITH CALIBRATION
PAUSE AFTER PROGRAM	18	AUTO FLAME OFF	YES

Figure 8.

A DELAY of two minutes is programmed at the start of the first program (15 iron) to ensure the burner is stabilized at its operating temperature. FIRST and LAST sample numbers are then entered, in this example 1 and 20.

The FIRST MEASUREMENT can be a calibration, a reslope or sample.

If CALIBRATION is selected the system will calibrate with the number of standards specified. If RESLOPE is selected this will be applied to the stored calibration for that element. If SAMPLE is selected the concentration values will be calculated from the stored calibration data. If there is no stored calibration then only the absorbance is measured. (Only copper will be determined using a previously stored calibration and thus the first measurement will be reslope.)

For the next program (17, calcium) a delay of 1 minute has been entered to allow the burner to reach its operating temperature with the nitrous oxide-acetylene flame. First and last sample numbers are entered as before. This procedure is followed for programs 18 (silicon), 13 (chromium), 19 (silicon) and 23 (molybdenum) but without the delay time.

A delay of three minutes is entered for program 9 (sodium) which will allow the burner to cool down to its operating temperature; first and last sample numbers being entered as before.

Sample numbers are entered for program 1 (copper) and first measurement is altered to RESLOPE. Sample numbers are entered for programs 7 (nickel) and 8 (manganese).

A delay of two minutes is entered for program 2 (lead) to allow the burner to reach its operating temperature as it will be changed before this determination. The relevant sample numbers are then entered for program 2 and 10 (arsenic).

The final entry to be made is PAUSE AFTER PROGRAM which appears at the bottom of the screen. This PAUSE facility can be used several times in a sequence, enabling carousels, standards and reslope standards to be replaced; burners to be exchanged, rotated, or their height adjusted; the VGA-76 to be fitted. Lamps can also be exchanged if nine or more elements are being determined and multi-element lamps are not being used.

The first PAUSE entry will be 18 which will enable the carousels to be exchanged. When the system automatically pauses after the completion of program 18, the operator can insert the next PAUSE request, in our example 8, to change the burner. Finally when this second pause command is acted upon during operation the operator can insert the last PAUSE request, in our example 2, to enable the VGA-76 to be installed.

Having completed the sequence control page the NOTES soft key is pressed then the REPORT FORMAT soft key. This screen enables the following to be displayed and printed on the report:

Operator name
Date
Batch name

and the report parameters selected:

Format	Sequential* or Multi-element
Data printed	Mean Concentration only* or Mean Concentration and %RSD or Mean Concentration, %RSD & Mean Absorbance or Each Reading (Mean Concentration, %RSD, Mean Absorbance and Every Absorbance Reading).
Print	During Run* or After Run or Manual
Instrument status	Yes or No*
Notes	Yes or No*
Calibration results	Yes* or No
Calibration graph	Yes or No*
Sample labels	Yes* or No
Lines per page	Select for page length used (usually 66)

See Figure 9. Parameters normally used are indicated by *.

PROGRAM 15	Fe in Water
NO. 1 BLANK	REPLICATE 1
ABSORBANCE	STANDARD ADDN'S BC ON
INTEGRATION	5.0 (sec) AIR-ACETYLENE
PRINTING	
REPORT FORMAT	
OPERATOR	B.D. FRARY
DATE	22 APRIL 1985
BATCH NAME	ST907;W113;SL536
FORMAT	SEQUENTIAL
DATA PRINTED	EACH READING
PRINT	DURING RUN
INSTRUMENT STATUS	NO
NOTES	NO
CALIBRATION RESULTS	YES
CALIBRATION GRAPH	NO
SAMPLE LABELS	YES
LINES PER REPORT PAGE	72

Figure 9.

If PRINT DURING RUN is selected then all the other features selected will be printed during the run. All results obtained after the start of the run can be inspected on the print-out. However when using PRINT MANUAL or PRINT AFTER RUN, only the results currently displayed on the screen are available for inspection.

The analytical run can be completed in a slightly shorter time if PRINT MANUAL is selected.

The absorbance values of all solutions are stored on the program disc as they are read (no matter which PRINT status is selected). If a power failure occurs during the analysis the only data lost will be that for the solution under analysis. No other data is lost or corrupted.

At the end of the analytical run all the data may be archived and a multi-element report produced. It is recommended that the data is archived before another run is performed as the program disc is cleared of data when START is pressed.

If SAMPLE LABELS is selected then a screen as shown in Figure 10 is displayed (up to 12 alphanumeric characters can be used). INCREMENT LABELS is a time saving facility. In Figure 10, W113 is the first water sample and is entered as sample 1. INCREMENT LABELS is pressed and samples 2 to 10 are automatically labelled W114 to W122. The cursor is moved to sample 11, relabelled SL536 and INCREMENT LABELS pressed. Samples 12 to 20 are automatically labelled SL537 to SL545. Finally the cursor is moved to sample 21, relabelled S907 and INCREMENT LABELS pressed. Samples 22 to 42 are automatically labelled S908 to S928. MORE LABELS is pressed, samples 43 to 67 are displayed and are automatically labelled S929 to S953.

PROGRAM 15	Fe in Slag	
NO. 1 BLANK	REPLICATE 1	
ABSORBANCE	STANDARD ADDN'S BC ON	
PEAK HEIGHT	8.0 (sec) AIR-ACETYLENE	
PRINTING		
SAMPLE LABELS		
1. W 113	2. W 114	3. W 115
4. W 116	5. W 117	6. W 118
7. W 119	8. W 120	9. W 121
10. W 122	11. SL 536	12. SL 537
13. SL 538	14. SL 539	15. SL 540
16. SL 541	17. SL 542	18. SL 543
19. SL 544	20. SL 545	21. ST 907
22. ST 908	23. ST 909	24. ST 910
25. ST 911	26. ST 912	27. ST 913
28. ST 914	29. ST 915	30. ST 916
31. ST 917	32. ST 918	33. ST 919
34. ST 920	35. ST 921	36. ST 922
37. ST 923	38. ST 924	39. ST 925
40. ST 926	41. ST 927	42. ST 928
MORE INCREMENT LABELS LABELS		

Figure 10.

Loading Off Carousels

Two carousels will be used, one for STANDARD ADDITIONS calibration (water samples 1 to 10, slag samples 11 to 20), the other for NORMAL calibration (steel samples 21 to 50).

The standard additions carousel will be loaded as follows:

Sample position	1 Blank
	2 Addition 1
	3 Addition 2
	4 Addition 0 (sample 1)
	5 to 13 Addition 0 (samples 2 to 10)
	14 Blank
	15 Addition 1
	16 Addition 2
	17 Addition 0 (sample 11)
	18 to 26 Addition 0 (samples 12 to 20)

The second carousel, for normal calibration will be loaded:

Multi-element standards in standard positions 1 to 5. Blank and reslope solutions in their respective positions. Water samples in sample positions 1 to 10 and steel samples in positions 21 to 50.

Operation

When the operator has fitted the required burner and carousel the flame is lit and START key pressed.

Operation proceeds as follows:

The system recalls the first program in the sequence (15) resets the sampler and checks all system parameters are correctly set. It waits 2 minutes for the burner to warm up while aspirating distilled water. It then carries out the calibration of the system with the addition standards for waters and measures the first 10 samples (waters). It then recalibrates the system with the addition standards for slags and measures samples 11 to 20 (slags).

The next program (17) is recalled and the system set up to these parameters. The burner is allowed to warm up for the programmed 1 minute before calibration proceeds. Samples 1 to 10 are then measured.

The next program (18) in the sequence is recalled and the system set up on these parameters. Calibration proceeds immediately as no delay has been programmed (the burner is already at its operating temperature). Samples 1 to 10 are measured for this element.

After sample 10 is measured the next program (13) is recalled and the system “beeps” to remind the operator that a programmed PAUSE has been reached. The operator presses STOP, changes carousels, alters PAUSE AFTER PROGRAM to 8 and presses START. As no delay has been programmed the system proceeds to calibrate and then measures samples 31 to 40. A RECALIBRATION is then carried out and samples 41 to 50 are measured.

Program 19 is then recalled, the system set up, calibration is performed and samples 21 to 35 are measured. RESLOPE is performed and samples 36 to 45 measured.

Program 23 is recalled, the system set up, calibration is performed and samples 41 to 50 measured.

Program 9 is recalled, the system is set up and changes to the air-acetylene gas mixture waiting for the 3 minutes programmed delay while the burner cools down to its operating temperature. Calibration is performed and samples 1 to 10 are measured.

Program 1 is recalled, the system set up, a RESLOPE is performed and applied to the stored calibration. If the reslope is correct, samples 21 to 36 are measured. A RESLOPE is performed and samples 37 to 50 measured.

Program 7 is recalled, the system set up, calibration is performed and samples 31 to 40 measured. A RECALIBRATION is performed and samples 41 to 50 measured.

Program 8 is recalled, the system set up, calibration is performed and samples 27 to 45 measured. Program 2 is recalled and the system “beeps” to remind the operator that a programmed PAUSE has been reached. The operator presses STOP, presses FLAME OFF, changes burners, alters PAUSE AFTER PROGRAM to 2 then presses IGNITE and START. The system waits 2 minutes for the burner to warm up then calibrates and measures samples 31 to 40. A RECALIBRATION is then carried out and samples 41 to 50 are measured.

Program 10 is recalled and the system “beeps” to remind the operator that a programmed PAUSE has been reached. The operator presses STOP and FLAME OFF, connects the VGA-76 hydride generator, replaces the carousel in use by the one for standard addition calibration and presses IGNITE. START is pressed, the system performs the calibration procedure and determines the arsenic concentrations of samples 1 to 10. After the last sample is determined the flame is automatically extinguished and the system “beeps” indicating the analytical run has been completed.

Archiving and multi-element report

The INDEX key is pressed and page 19 UTILITIES selected. From the display ARCHIVE is selected followed by the file (on the utilities disc) for archiving. The ARCHIVE soft key is pressed and the data is permanently stored.

After returning to the UTILITIES index, PRINT REPORTS is selected. From the next display the data set required is chosen and then the elements required. REPORT FORMAT soft key is pressed and the following is displayed:

Format Sequential or multi-element*

Data printed Mean concentration only* or
Mean concentration and %RSD or
Mean concentration, %RSD and mean
absorbance or
Each Reading (Mean Concentration,
%RSD, Mean Absorbance and Every
Absorbance Reading).

Instrument status Yes or No*

Notes Yes or No*

Calibration results Yes* or No

Calibration graph Yes or No*

Sample labels Yes* or No

Weight correction Yes* or No

Lines per page Select for page length used (usually 66)

Parameters normally used are indicated by *

If WEIGHT CORRECTION is selected the measured concentration of the elements in the samples is automatically calculated before print out. This is a time (and error) saving facility.

PRINT REPORT is pressed and the multi-element report is duly obtained (Figure 11).

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Operator	B.D. FRARY					
Date	22 April 1985					
Batch	ST 907/953; W 113/122; SL 536/545					
Program 15	Fe in Slag					
Program 17	Ca in Slag					
Program 18	Si in Slag					
Program 13	Cr in Steel					
Program 19	Si in Steel					
Program 23	Mo in Steel					
Program 9	Na in Water					
Program 1	Cu in Steel					
Program 7	Ni in Steel					
Program 8	Mn in Steel					
Program 2	Pb in Steel					
Program 10	As in Water					
	Fe *	Ca %	Si %	Cr %	Si %	Mo %
BLANK CONC	0.00	0.0	0.0	0.00	0.00	0.00
STANDARD 1 CONC				18.00	0.10	
STANDARD 2 CONC				20.00		0.10
STANDARD 3 CONC					0.25	0.25
STANDARD 4 CONC						0.50
STANDARD 5 CONC					0.50	
ADDITION 1 CONC	1.00	10.0	5.0			
ADDITION 2 CONC	2.00	20.0	10.0			
W113 CONC	1.12					
W114 CONC	0.98					
SL 542 CONC	3.63	41.6	12.4			
SL 543 CONC	2.54	45.3	19.2			
ST 918				18.3	0.09	0.013
ST 919				17.9	0.11	0.019
* Concentration Units not shown as will be ppm in Water samples and % in Slag samples.						

Figure 11.

As all the analytical data is now archived other reports can be generated at any time if required. For example a report showing all data for arsenic (program 25) is required. This is easily produced by:

- Accessing the utilities disc, selecting the appropriate archive file, then selecting the element to be printed (in this case arsenic). Proceed to report format via the soft key and select the options required, then print report.
- The SpectrAA- system can be used for an automatic run in the same way. However as it has a manually operated turret the operator must bring the next lamp into the operating position when prompted by the DS-15. If multi-element lamps are used then this requirement is reduced or even eliminated.

References

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